Water Quality Standards **Discussion Paper**

A REFERENCE CONDITION METHOD FOR QUANTITATIVE APPLICATION OF THE "NATURALLY OCCURRING" STANDARD

SUMMARY

At the May 10, 2004 Water Quality Standards Advisory Committee (WQSAC) meeting, DES presented a first draft of a discussion paper to implement a procedure for quantitative application of the narrative standard of "none unless naturally occurring" for color, turbidity, nitrogen, and phosphorus in Class A waterbodies. For that discussion, data from 60 lakes were used: 30 reference and 30 non-reference lakes. All available summer upper layer data were used so that each lake was not represented by an equal number of data points. DES has continued work on this issue, increasing the number of lakes and using data from different depths and seasons, but only from the most recent year of sampling so that each lake is represented by essentially the same number of data points. This paper describes the methodology used and the results obtained from this additional work. The May 10th paper follows this discussion as Appendix A and provides the background and regulations involved.

METHODOLOGY

1. One hundred lakes were selected for analysis, 50 reference and 50 non-reference (the earlier analysis evaluated 60 lakes, 30 of each group). The 50 lakes include the 30 in the original analysis along with an additional 20 lakes. Fifty (a subset 50 of randomly selected lakes) is the number used by EPA to characterize a population of lakes.

2. The lakes were not selected randomly. They were selected from a visual inspection of a set of New Hampshire topographic maps. Reference lakes had little development in the watershed and limited shoreline development. In contrast, non-reference lakes had development (mainly highways, roads and urbanized areas) within the watershed and/or dense shoreline development. Lakes were NOT selected based on existing water quality. In fact, since people tend to build first on the "best" lakes, many high quality lakes were considered to be non-reference because of dense shoreline development. An attempt was made to have a similar distribution of lakes in each group relative to size, elevation and geographic distribution.

3. Sample results for all depths and all dates from the most recent year of sampling were used. For all lakes, this consisted of two winter samples collected at 1/3 and 2/3 the water depth and two to three summer samples collected at 1/3 and 2/3 the water depth for thermally unstratified lakes or at the mid-epilimnion, mid-metalimnion and mid-hypolimnion depths for thermally stratified lakes. Thus each lake had 4 or 5 samples, resulting in 200 to 250 data points for each group of 50 lakes (in contrast, the earlier analysis used summer, upper water layer samples only, but for all dates, so that some lakes were represented by 1 sample value while other were represented by several values).

4. Values that were below the detectable limit (‘less than’ values) were treated according to the table below.

parameter	detection limit	value used
total phosphorus (mg/L)	0.001	0.0005
	0.005	0.002
apparent color (units)	5	2
total Kjeldahl nitrogen (mg/L)	0.1	0.05
	0.25	0.1
	0.5	delete
nitrite + nitrate nitrogen	0.02, 0.05	0.02 & delete
turbidity (NTU)	1,2	delete
Secchi disk (m)	visible on bottom	delete

RESULTS

1. Lake characteristics

An attempt was made to have a similar distribution of reference versus non-reference lakes relative to their geographical distribution and morphological characteristics. The table below shows the extent of success for this attempt.

parameter	minimum	maximum	mean	median
reference lakes				
latitude (ddmmss)	424610	451707		432726
area (ha)	4.0	520.4	36.5	18.0
mean depth (m)	1.2	12.2	4.4	3.6
maximum depth (m)	2.5	31.4	11.1	9.5
elevation (ft)	295	2410	1216	1199
watershed area (ha)	38.8	9298.1	585.3	207.2

non-reference lakes				
latitude (ddmmss)	424525	450449		431218
area (ha)	4.6	493.7	80.4	44.3
mean depth (m)	1.2	9.8	4.2	3.6
maximum depth (m)	2.7	28.9	10.2	8.0
elevation (ft)	118	1575	535	476
watershed area (ha)	81.0	119139	8246.0	657.8

As can be seen by the minimum and maximum values, both groups of lakes had representatives from both ends of the spectrum for each parameter. On average both groups had similar mean and maximum depths and a similar distribution from north to south (similar median latitude). However, based on the mean and median values, the reference lakes tended to be smaller, higher elevation ponds with smaller watersheds.

2. Total phosphorus

Total phosphorus in mg/L

group	# datapoints	minimum	maximum	mean	median	25 %	75 %
reference	218	.0005	.083	.011	.008	.006	.013
non-reference	224	.002	.217	.014	.010	.007	.015

Although the non-reference group of lakes had a much higher maximum total phosphorus value, there was little difference between the medians and 25th and 75th percentiles for the two groups.

3. Apparent color

Apparent color (units)

group	# datapoints	minimum	maximum	mean	median	25 %	75 %
reference	217	2	130	28	20	9	40
non-reference	219	2	140	30	24	14	38

There was little difference between the two groups of lakes for all statistics including the maximum value.

4. Total Kjeldahl nitrogen

Total Kjeldahl nitrogen (mg/L)

group	# datapoints	minimum	maximum	mean	median	25 %	75 %
reference	183	.02	1.36	.31	.28	.19	.40
non-reference	198	.05	3.93	.38	.31	.20	.50

Similar to total phosphorus, the maximum for the non-reference lakes was much higher than for the reference lakes but there was little difference in the median values.

4. Nitrite + nitrate nitrogen (BD values = 0.02)

Nitrite + nitrate nitrogen (mg/L)

group	# datapoints	minimum	maximum	mean	median	25 %	75 %
reference	169	.02	.40	.05	.02	.02	.06
non-reference	195	.02	.59	.06	.02	.02	.08

Two-thirds of the reference lakes and over half of the non-reference lakes had nitrite plus nitrate values below the detectable value (compare the number of data points with the table below where the below detectable values were deleted). In this table the below detectable values were all converted to 0.02 mg/L. There was essentially no difference between the two groups for this nitrogen parameter.

5. Nitrite + nitrate nitrogen (BD values deleted)

Nitrite + nitrate nitrogen (mg/L)

group	# datapoints	minimum	maximum	mean	median	25 %	75 %
reference	56	.02	.40	.10	.07	.06	.12
non-reference	91	.02	.59	.12	.08	.06	.16

Here we deleted all below detectable values but there was still very little difference between the two groups of lakes.

6. Turbidity

Turbidity (NTU)

group	# datapoints	minimum	maximum	mean	median	25 %	75 %
reference	21	.10	1.80	.89	.93	.69	1.20
non-reference	114	.30	23.0	2.28	1.10	.60	1.90

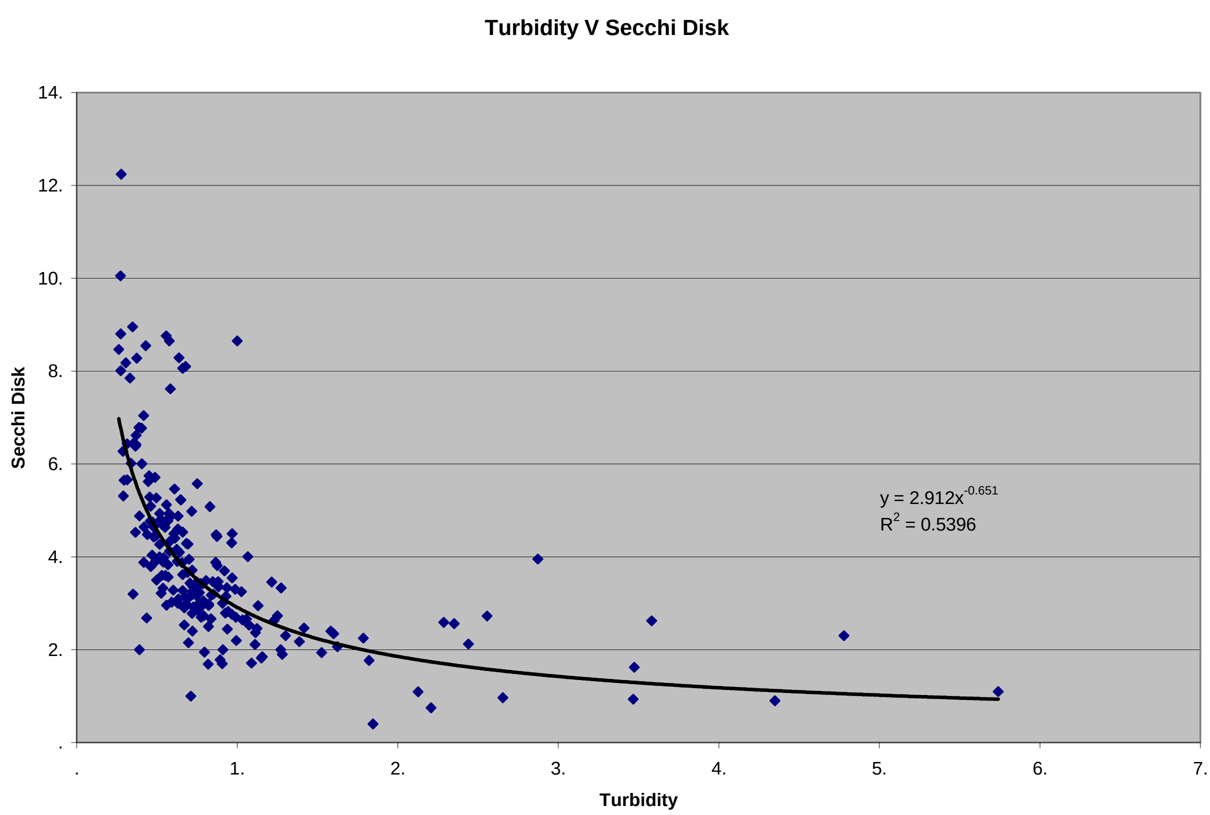
Limited turbidity values were available, particularly for the reference lakes. While the maximum value for non-reference lakes was much higher than for the reference lakes – and consequently the mean value was somewhat elevated - there was little difference between the median or percentile values for the two groups.

7. Secchi disk transparency

Secchi disk (m)

group	# datapoints	minimum	maximum	mean	median	25 %	75 %
reference	44	0.8	11.4	4.6	4.2	2.5	6.0
non-reference	45	1.2	10.2	4.0	3.6	3.4	4.8

There are less than 50 data points for each group because Secchi disk readings are only taken during the summer, only one reading per sample date is taken and “visible on bottom” values were deleted. Note that for this parameter, the higher the value the ‘better’ the water quality. Secchi transparency is not one of the criteria with a “none unless naturally occurring” statement. However, because of the relationship between Secchi transparency and turbidity, as shown in the graph below, we can use the Secchi numbers to estimate the turbidity numbers.



Turbidity based on relationship with Secchi values

group	# datapoints	minimum	maximum	mean	median	25 %	75 %
reference		.12	7.29	.50	.57	.33	1.26
non-reference		.15	3.90	.61	.72	.46	.79

The turbidity values in the above table were derived from the Secchi values and the relationship in the above graph. Because of the inverse relationship between the two parameters (as Secchi increases, turbidity decreases), the minimum Secchi value is related as the maximum turbidity value and the maximum Secchi value is related as the minimum turbidity value.

CONCLUSION

The fact that there was little difference in the statistics between the reference and non-reference groups of lakes for most of the parameters does not preclude the use of reference conditions as an estimate of natural conditions. It merely means that existing watershed development has not significantly impacted water quality for these parameters. DES proposed (see Appendix A) using the 75^{th} percentile value for the population of reference lakes as the upper limit for a "naturally occurring" value. The table below presents this upper limit value for each parameter.

parameter	"naturally occurring" value
total phosphorus (mg/L)	0.013
apparent color (units)	40
total Kjeldahl nitrogen (mg/L)	0.40
nitrite + nitrate nitrogen (mg/L)	0.06
turbidity (NTU)	1.26

SAMPLING PROTOCOL

The protocol for sampling a lake to determine its "average" value, i.e., to determine if the lake's value is less than or equal to the "naturally occurring" value, is outlined below and is based on NHDES' Consolidated Assessment and Listing Methodology (CALM) protocols.

1. The deep spot of the lake is sampled. *(This is subject to discussion. While the data set used to determine the naturally occurring values was from the deep spot, it may be appropriate to sample at the location of the intake pipe creating the water transfer).*
2. A lake is sampled a minimum of ten times, separated by at least one day.
3. A lake can be sampled in winter (2 samples at 1/3 and 2/3 the water depth) or summer (3 samples if thermally stratified [mid depth of each thermal layer] or 2 depths if unstratified [1/3 and 2/3 water depth]. The worst case value for each sampling date is used as the value for that date. *(The use of the worst case value is based on the CALM protocol; however, all data for a given sampling date , not just worse case values, were used in*

developing the reference values. Also, although not part of the original data set, I would argue that samples could also be collected at spring or fall overturn and that only one sample (mid depth) needs to be collected at that time. I would also suggest that we require a minimum of two different seasons be sampled and perhaps a maximum number of samples per season (e.g., at least 10 samples and no more than 7 from any one season).

4. No more than two of the 10 worst case sample values can exceed the naturally occurring value to be considered natural.

RELATIONSHIP OF ‘NATURALLY OCCURRING’ TO ANTIDEGRADATION

Under the proposed Env-Ws 1708.12(d), the transfer of water shall be considered significant for the purposes of antidegradation, which means that a full antidegradaation review is required before any water transfer can occur. In other words, for a water transfer to occur to a Class A lake, values for the above-listed ‘none unless naturally occurring’ parameters must be less than or equal to the ‘naturally occurring’ reference values AND an antidegradation review must completed. The anitdegradation review addresses the issue of the source water meeting the reference conditions but exceeding the receiving water conditions. For example, a request is received to transfer water of color 30 to a Class A lake with color 5. The proposed transfer is not automatically prohibited by the “none unless naturally occurring” provision because 30 is less than the reference value of 40, but it may not be allowed if the antidegradation review determines that the transfer would increase the color of the receiving water to an unacceptable level.

Appendix A

May 10, 2004 Discussion Paper

A REFERENCE CONDITION METHOD FOR QUANTITATIVE APPLICATION OF THE “NATURALLY OCCURRING” STANDARD

SUMMARY

DES proposes to implement a procedure for quantitative application of the narrative standard of “none unless naturally occurring for color, turbidity, temperature, oil and grease, nitrogen, and phosphorus in class A waterbodies. The procedure would use statistical analysis of data from reference sites to determine a numerical upper limit for “naturally occurring” by waterbody type that is equal to the 75th percentile value for the population of reference sites.

BACKGROUND

DES and the Water Quality Standards Advisory Committee (WQSAC) have been considering rule changes to create a process so that water transfers from one waterbody to another can be determined to comply with water quality standards and considered for NPDES permits. A previous discussion paper (1) applies. The remaining issue to be resolved is that the "none unless naturally occurring" narrative standard for color, turbidity, temperature, oil and grease, nitrogen, and phosphorus that applies in class A waterbodies would seem to result in de facto prohibition of transfers to these waterbodies.

Options discussed by the committee include: 1) legislative reclassification of class A waterbodies to class B before a transfer can be considered; 2) changing the "none unless naturally occurring" language for color, turbidity, temperature, oil and grease, nitrogen, and phosphorus in class A waterbodies; 3) creating an exception to the "none unless naturally occurring" language that applies only to waterbodies receiving water transfers; and 4) redefining "naturally occurring"

Informal legal review by DES recommends that, because the "none unless naturally occurring" language occurs in rule and not in the legislative requirements for class A there should be a rule change that will accomplish the intended purpose of allowing water transfers to class A waterbodies, with appropriate safeguards and restrictions. Legislative reclassification is not needed or appropriate.

It was pointed out in discussions at the 3/22/2004 WQSAC meeting that creating an exception to the "none unless naturally occurring" language that applies only to waterbodies receiving water transfers would result in no standard at all for these waterbodies for these parameters, and if a different standard were adopted for these waterbodies, then a new subclass would be created, with a different ambient standard for color, turbidity, temperature, oil and grease, nitrogen, and phosphorus. DES does not want to create a new subclass.

Also at the 3/22/2004 WQSAC meeting, it was the sense of the committee that removing or changing the "none unless naturally occurring language would not be a good idea.

The remaining option is to redefine "naturally occurring". DES proposes to do this by applying a translator procedure that estimates a range of numerical values for naturally occurring color, turbidity, nitrogen, and phosphorus by waterbody type, rather than by changing the rule definition.

APPLICABLE LAWS AND REGULATIONS (Excerpts)

Env-Ws 1702.29 "Naturally occurring conditions" means conditions which exist in the absence of human influences.

Env-Ws 1703.10 Color.

(a) Class A waters shall contain no color, unless naturally occurring.

Env-Ws 1703.11 Turbidity.
(a) Class A waters shall contain no turbidity, unless naturally occurring.

Env-Ws 1703.14 Nutrients.
(a) Class A waters shall contain no phosphorus or nitrogen unless naturally occurring.

DISCUSSION

The idea of “reference condition” for waterbodies has been widely used in recent years in the development of numeric biological criteria for aquatic life use support, and has also been proposed in EPA guidance documents for development of numeric nutrient criteria. A reference condition is one in which the waterbody and its tributary watershed are minimally impacted by human activity, so that measurable attributes of water quality and aquatic life are as close as possible to conditions which would exist in the absence of human influences. A further description of the concept may be found at http://www.epa.gov/waterscience/biocriteria/alus/ref2.html.

For an identified population of reference sites, the natural variability of a water quality parameter can be estimated from the distribution of parameter values. Naturally occurring conditions, or conditions indistinguishable from naturally occurring, can then be defined as some statistic of the distribution. For example, values less than the 75th percentile of the population of parameter values might be considered to be naturally occurring. Using this procedure, water quality parameters for any waterbody would be considered to be “as naturally occurs” if they fit within the prescribed statistic of the reference population of values.

DES has conducted a preliminary analysis for lakes for color, turbidity, phosphorus, and nitrogen. A total of 60 ~~70~~ lakes for which DES has data were evaluated. Thirty were estimated to be reference conditions, and this estimation was confirmed using GIS-based tests for human disturbance such as road density and percent developed land. For comparison, 30 ~~36~~ lakes were chosen that were estimated to have great human disturbance in their watershed. Turbidity data was available for only 13 of the 60 lakes evaluated (1 reference vs 12 non-reference). Population statistics were generated for both reference lakes and non-reference lakes (table 1). Figures 1-4 are box and whisker plots showing the same information graphically.

Table 1

	Reference					Non-Reference				
	Color	Nitrate (mg/L)	Total P (mg/L)	Turbidity (NTU)	TKN (mg/L)	Color	Nitrate (mg/L)	Total P (mg/L)	Turbidity (NTU)	TKN (mg/L)
90th Percentile	38.00	0.10	0.03	0.68	0.46	47.00	0.06	0.02	1.59	0.50

75th Percentile	20.75	0.05	0.01	0.65	0.30	35.00	0.05	0.02	1.15	0.40
25th Percentile	7.25	0.05	0.01	0.25	0.16	15.50	0.05	0.01	0.53	0.26
10th Percentile	2.50	0.02	0.00	0.24	0.11	10.00	0.02	0.01	0.41	0.17
Mean	22.00	0.05	0.01	0.42	0.25	27.00	0.05	0.01	0.92	0.34
# Observations	36	34	37	9	33	67	63	70	114	62

Figure 1

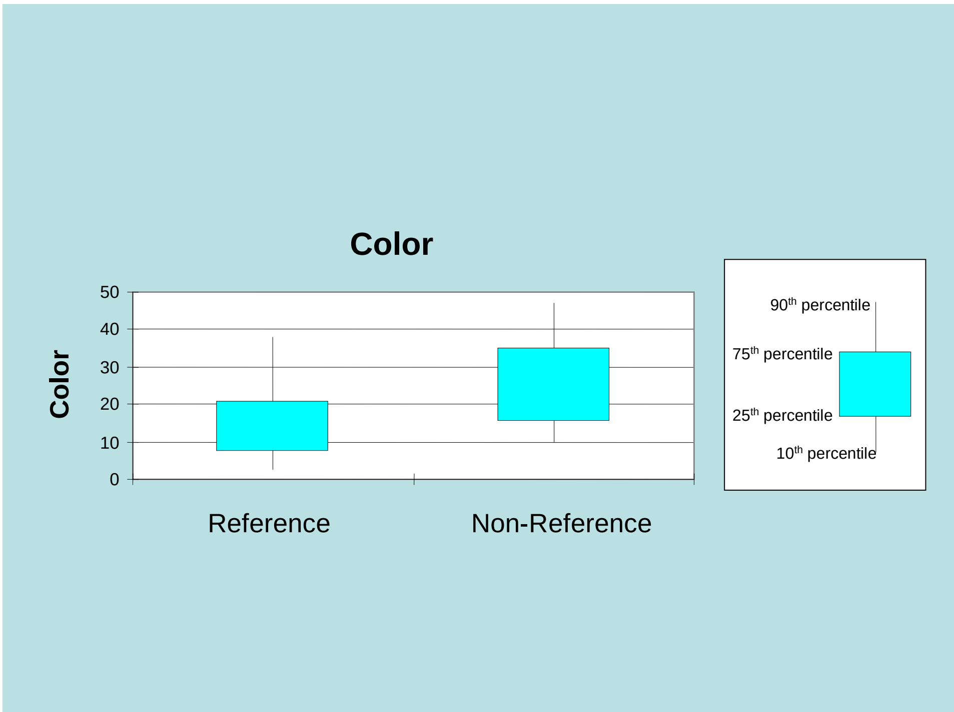


Figure 2

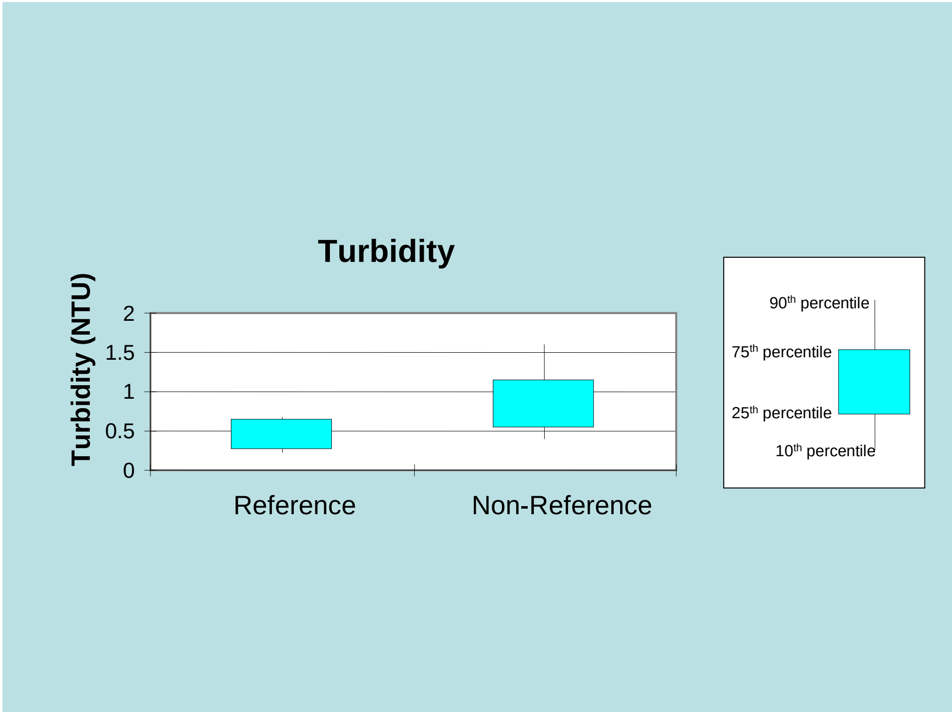


Figure 3

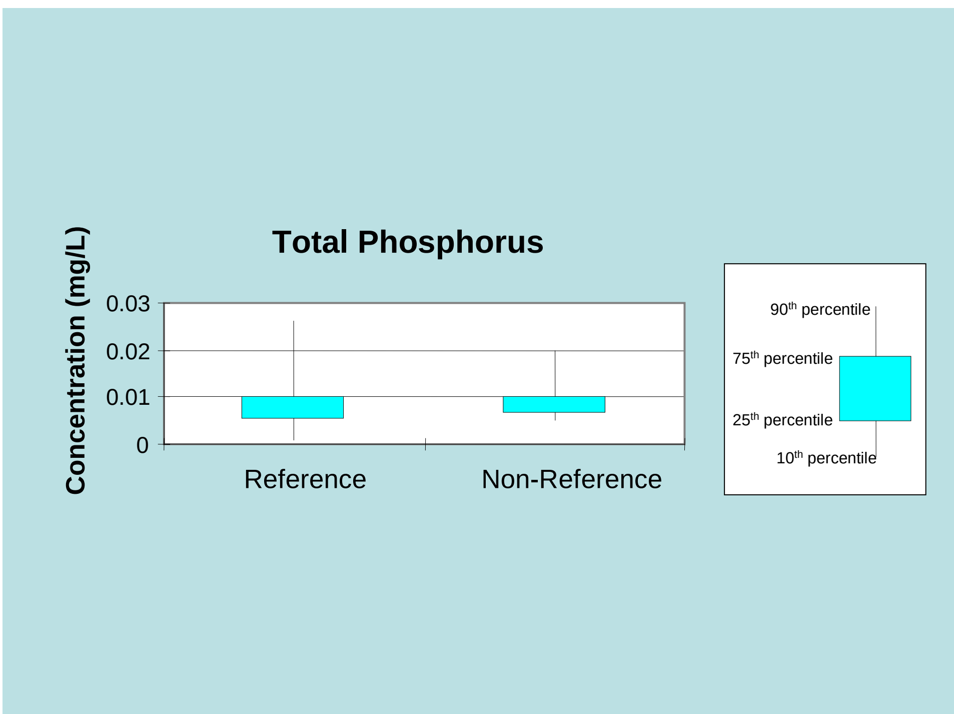


Figure 4

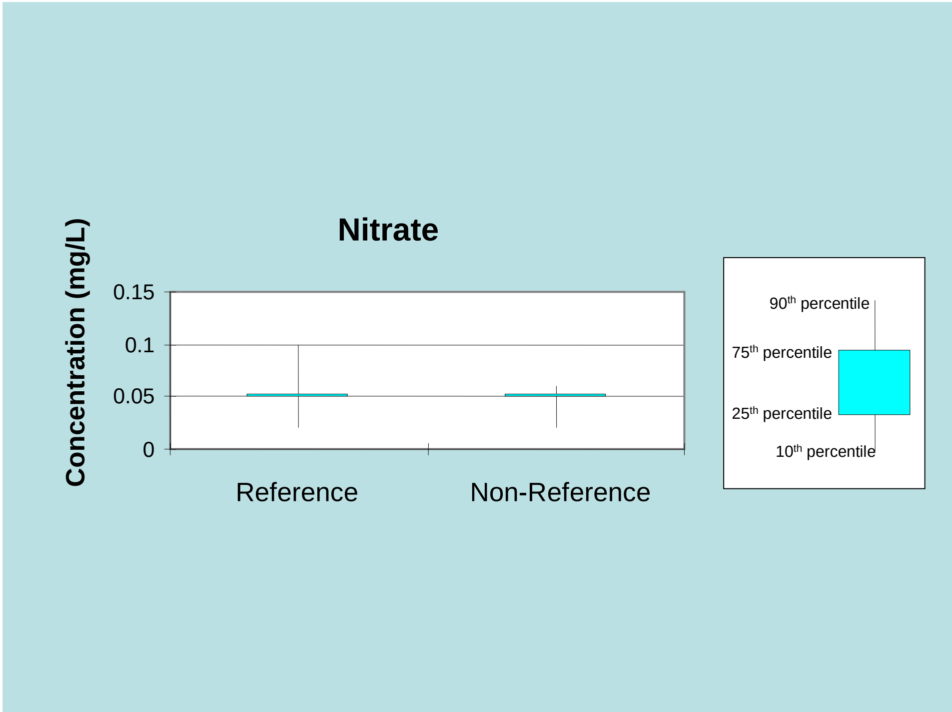
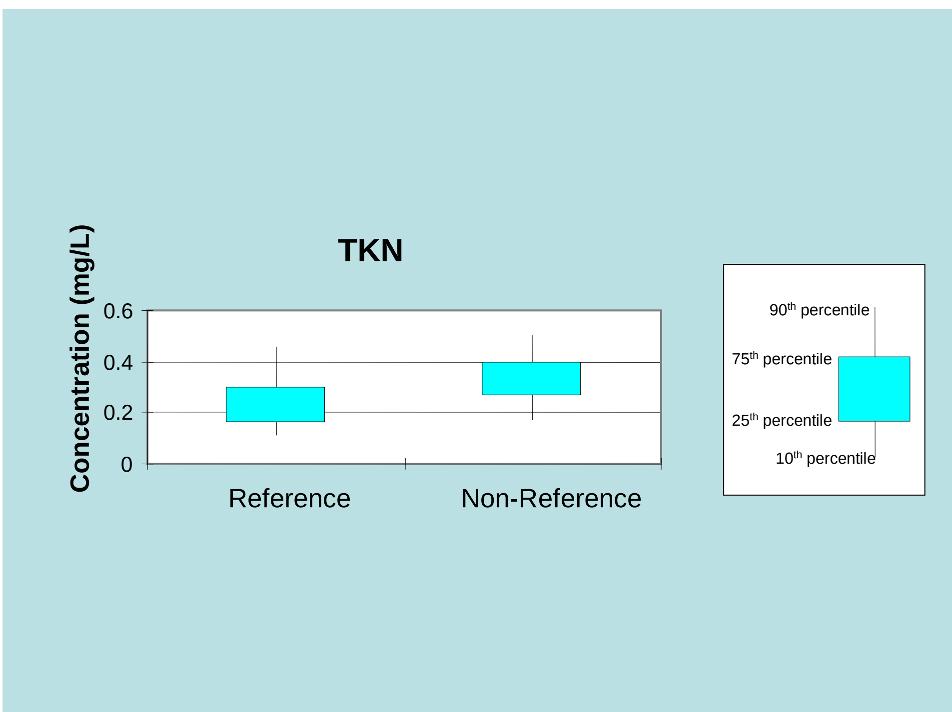


Figure 5



PROPOSAL

DES proposes that, for lakes, values of color, turbidity, nitrogen, and phosphorus that are less than the 75th percentile value of the population of reference lakes be considered "as naturally occurs". A value greater than the 75th percentile would be considered "as naturally occurs" only if a watershed survey determines that there is minimal human activity in the watershed, or there is a dominant natural watershed characteristic causing the value.

The reference population selected for this discussion paper is preliminary, and may change after further analysis. Using this approach and the preliminary reference population, a color value of 20.75 or less, a phosphorus value of .01 mg/l or less, a total nitrogen (=nitrate + TKN) of .35 mg/l or less, and a turbidity of .65 NTU or less would be considered "as naturally occurs" for lakes.

DES would conduct similar analyses for other waterbody types to apply the "naturally occurring" narrative standard to particular waterbodies, as the need arises.